EXHIBIT 6

Does the LIBOR reflect banks' borrowing costs?

Connan Snider* UCLA

Thomas Youle† University of Minnesota

April 2, 2010

Abstract

The London Interbank Offered Rate (Libor) is a vital benchmark interest rate to which hundreds of trillions of dollars of financial contracts are tied. Recently observers have raised concerns that the Libor may not accurately reflect average bank borrowing costs, it's ostensible target. In this paper we provide two types of evidence that this is the case. We first show that bank quotes in the Libor survey are difficult to rationalize by observable cost measures, including a given bank's quotes in other currency panels. Our second type of evidence is based on a simple model of bank quote choices in the Libor survey. The model predicts that if banks have incentives to affect the rate (as opposed to simply reporting costs), we should see bunching of quotes around particular points and no such bunching in the absence of these incentives. We show that there is strong evidence of the predicted bunching behavior in the data. Finally, we present suggestive evidence that several banks have large portfolio exposures to the Libor and have recently profited from the rapid descent of the Libor. We conjecture that these exposures may be the source of misreporting incentives.

*Department of Economics, UCLA, snider@econ.ucla.edu, ph: (310) 794-7104.

†Department of Economics, University of Minnesota, youle001@umn.edu, ph: (612) 298-4807.

1 Introduction

The London Interbank Offered Rate (Libor) is a widely used benchmark interest rate, intended to reflect the average rate at which banks can borrow unsecured funds from other banks. The rate is set each day by taking a truncated average of the reported borrowing costs of a panel of 16 large banks. Since its introduction in 1986, the Libor has steadily grown in importance and is now among the most widely used benchmark rates in financial contracting. The British Bankers Association (BBA) estimates that $10 trillion of loans and $350 trillion of swaps alone are indexed by the Libor. Since the upheaval in financial markets that started around August of 2007, the Libor has diverged from many of its historical relationships causing market observers to question its proper functioning. An influential article by Mollenkamp and Whitehouse (2008) argued that the Libor was too low in this period and suggested that banks in the panel were intentionally quoting low rates in order to burnish the markets' perception of their riskiness.

In this paper we provide three types of evidence that banks' Libor quotes may not reflect true borrowing costs. First, we corroborate the Mollenkamp and Whitehouse (2008) finding that bank Libor quotes are very weakly related to other measures of bank borrowing costs, in particular to the price of default insurance. Second, we find it is common for pairs of banks who participate in multiple currency-Libor panels to have different rank orderings in different currencies. This implies that the quoted rates cannot be expressed as the sum of currency specific variables and bank specific variables. Yet most of the variables we would consider important for pricing debt either do not vary across banks, such as the expectations for future inflation, or do not vary across currencies, such as the probability a given bank will default.

The third type of evidence comes from the intraday distribution of Libor quotes. We present a simple model of bank quote submission in which members may or may not have incentives to misreport. The model predicts, in the presence of misreporting incentives, we should see "bunching" of quotes at particular points. This prediction is due to the form of the rate setting mechanism, which averages the middle eight quotes of the sixteen. If a given bank has incentives to change the Libor (as opposed to simply reporting costs) and it knows the exact location of the pivotal fourth and twelfth quotes, its own quotes will tend to cluster around these pivotal quotes. This is because the marginal impact of that bank's quote on the overall rate, and thus the marginal benefit of changing the rate, goes to zero at these pivotal points. Quotes of banks without these misreporting incentives, should not exhibit this clustering behavior.

We find strong evidence of quote bunching behavior consistent with the model. We also show that the intraday distribution of other measures of bank borrowing costs do not exhibit this bunching pattern. Under the reputational theory of misreporting, a bank cares about how the market perceives it's own quote and not the Libor fix itself. It therefore, does not predict that banks will bunch around the pivotal quotes. In this sense, we present evidence in favor of our hypothesis

and against the reputation hypothesis and discuss the different policy implications of our results. Moreover, using more recent data, we find evidence of misreporting is stronger in the period *since* markets have calmed somewhat from their recent upheaval.

After establishing our arguments for the existence of misreporting incentives, we go on to explore the magnitude of the quote skewing and the sources of the incentives. To get a sense of the magnitude of skewing we compare the behavior of Libor quotes with the behavior of actual market lending rates in the Eurodollar market. We assume that in a benchmark (pre-financial crisis) period there was a relationship, similar to a bid-ask spread, between the Eurodollar rate and the Libor and that banks were truthfully reporting their costs in this period. We then measure the degree of skewing as the divergence in this relationship after the benchmark period. By this measure, we find that the magnitude of skewing is upwards of 40 basis points for some banks.[1]

Finally, we present suggestive evidence that the misreporting incentives are partially driven by member bank portfolio positions. We find that several banks in the U.S. Libor panel have very large interest rate derivative portfolios, have significant unhedged exposures to U.S. interest rates, and have profited from their interest rate derivative portfolios during the rapid descent of the Libor during 2009. We also argue the direction of bank skewing behavior is consistent with these portfolio incentives. We then examine banks included in several currency Libor panels who have financial incentives to raise some of the Libor rates and to lower the other rates. We find, as our model predicts, that they simultaneously submit quotes near the upper and lower pivotal points in the respective currencies.

The rest of the paper proceeds as follows: In section 2 we present evidence of the apparent lack of relationship between bank quotes and measures of bank costs as well as evidence of cross currency rank reversals. Section 3 presents our evidence of strategic behavior suggested by the simple model we lay out in the appendix. We also present our Eurodollar bid rate-based counterfactual analysis in this section Section 4 presents our evidence that several panel banks have large Libor positions and have recently profited from a low Libor. Section 5 concludes.

2 Libor Quotes and Bank Borrowing Costs

In a competitive interbank lending market, banks' borrowing costs should be significantly related to their perceived credit risk.[2] If the Libor quotes express true, competitively determined borrowing costs, then we should expect the quotes to be related to measures of credit risks, such as the cost of default insurance. Mollenkamp and Whitehouse(2008) were the first to point out the anomalous

[1] We also emphasize the limitations of this, at best, back of the envelope exercise. There has also been some concern that the Eurodollar Bid rate data is unreliable.

[2] When credit risk is private information, it is possible for credit to be rationed and for risky and safe borrowers to recieve the same interest rates, as in Stiglitz and Weiss (1981). Here we focus on risk measures that are public information, such as market prices for default insurance.

behavior of bank Libor quotes with respect to bank risk measures, credit default swap (CDS) spreads in particular.[3]

Figure 1 shows the 12 Month U.S. Libor quotes for Citigroup and the Bank of Tokyo-Mitsubishi along with their corresponding 1 Year Senior CDS spreads. The first puzzling fact is that while Citigroup has a substantially higher CDS spread than Mitsubishi, it submits a slightly lower Libor quote. The CDS spreads suggest that the market perceives Citigroup as risker than Mitsubishi, as it is more expensive to insure against the event of Citigroup's default. The Libor quotes, however, tell the opposite story. If Citigroup and Mitsubishi were truthfully reporting their costs, then the quotes suggest that market participants view lending to Citigroup as slightly safer than Mitsubishi.

A second puzzling pattern is the *level* of Citigroup's CDS spreads relative to its Libor quotes. Given that purchasing credit protection for a loan makes the loan risk free, one would expect difference between the loan rate and the CDS spread to roughly equal the risk free rate. This corresponds to the idea that a loan's interest rate contains a credit premium, here measured by the CDS spread. If loan rates contain other premia, such as a liquidity premia to compensate for the illiquidity of loans, then the loan rate should *exceed* the sum of the CDS spread and the risk free rate. In figure 1??, however, we see that Citigroup's quote is often significantly below its CDS spread. This implies that there were interbank lenders willing to lend to Citigroup at rates which, after purchasing credit protection, would earn them a guaranteed 5 percent loss.

The Mollenkamp and Whitehouse analysis and figure 1 paint a picture somewhat at odds with the findings of Taylor and Williams (2008a, 2008b) who find evidence that, at the level of the Libor fix, increasing bank risk *does* explain much the behavior of the rate. Table 1 displays the results of regressions similar to those performed in Taylor and Williams, now including more recent data up to October 2009. The dependent variable in the first specification is the spread between the 3 month U.S. Libor and the 3 month rate on Overnight Index Swaps (OIS).[4] Regressing the overall Libor fix on the Median CDS spread delivers a coefficient of 0.621 which is within the range of coefficients found by Taylor and Williams in their earlier period.

In the next four specifications the dependent variable is the spread of a bank's submitted Libor quote over the OIS rate, and is regressed on the bank's corresponding CDS spread. Now, at the bank level, we find a smaller effect. Controlling for bank-level heterogeneity in the spreads reduces the coefficient further and it becomes negligible once we control for serial correlation in the error

[3]Credit default swaps are bilateral agreements where one party, the Guaranteer, will pay another, the Beneficiary, if a particular reference entity defaults. The Guaranteer will pay $(1 - R)V$ where R is the recovery rate of the obligations determined in bankruptcy, so that, if the Beneficiary has V amount of obligations owed by the reference entity, the return in the event of default is $RV + (1 - R)V = V$. Purchasing an equal amount of CDS protection makes the debt risk free. In return for this protection the Beneficiary periodically pays rV to the Guaranteer, where r is the 'CDS spread'.

[4]Overnight Index Swaps (OIS) are agreements where one party pays a fixed rate in return for a series of floating payments based on an index such the federal funds rate. As the most that can be lost in the event of default is the foregone payments accruing over a short period, they are considered to be considerably safer than bonds and their spread usually considered risk free.

Table 1: Bank-level 3 Month LIBOR-OIS Spreads

	LIBOR	Bank-level LIBOR quotes			
		Pooled OLS	Random Effects	Random Effects AR(1) Error	Fixed Effects
Median CDS	0.621 (0.035)				
CDS		0.474 (0.102)	0.373 (0.098)	0.039 (0.009)	0.038 (0.009)
Constant	0.173 (0.020)	0.112 (0.036)	0.333 (0.067)	0.505 (0.085)	0.921 (0.001)
N	581	19235	7839	7839	7824
R^2	0.296	0.372			
Within R^2			0.199	0.199	0.002
Between R^2			0.001	0.001	0.005
ρ				0.995	0.995

terms. The estimated serial correlation is reported as ρ and is very large, as might be expected when working with daily frequency data. After controlling for serial correlation, CDS spreads are unable to explain the Libor quote variation between banks as well as the Libor quote changes within a bank through time.

The BBA has maintained that, in times of crisis, CDS spreads are not necessarily a better measure of bank borrowing costs than Libor quotes (Mollenkamp and Whitehouse 2008). More evidence can be found by looking at bank behavior in other currency Libor's.

Many banks participate in multiple Libor mechanisms and presumably there is some relationship between a bank's costs in these different markets. It is common for a bank included in multiple currency Libor panels to simultaneously quote a higher rate than another bank in one currency panel and lower rate in another currency. Figure 2 shows the differences in bank quotes in two currencies for four pairs of banks. We see that is is common for Bank of America to quote a lower rate than the Bank of Tokyo-Mitsubishi in the yen-Libor while submitting a lower quote in the US-Libor. Since the same bank is participating in each currency, the credit risk is the same for loans in either currency.[5] This shows that differences in banks' Libor quotes are not primarily due to differences in credit risk, something we would expect of their true borrowing costs.

The significance of these rank reversals is it that they show that either Libor quotes cannot be expressed as the sum of bank specific variables and currency specific variables, or banks cannot be

[5]While bankruptcy laws vary across countries they do not vary across the currency denomination of the obligations.

reporting true costs.[6] In contrast, most of the variables that we would expect to be important for pricing debt either do not vary across banks or do not vary across currencies. If banks were truly reporting their costs, then there must be large and persistent bank-currency specific risks concerning lenders. While it is possible there could be such effects, such as bank-currency specific liquidity risks, it is less clear that they are important enough to rationalize the magnitude and persistence of the reversals we observe in figure 2. An alternative explanation would be that in some currencies banks are submitting quotes that are too low. In our earlier discussion, if Citigroup was submitting a quote in the U.S. Libor that was below their true borrowing costs, while a submitting a correct quote in the Yen Libor, this could appear as a rank reversal if Bank of Tokyo quoted true costs in both currencies. We return to this example later.

3 Quote Bunching

Our final source of evidence comes from the intraday distribution of bank quotes. First we find that, relative to CDS spreads, Libor quotes are closely clustered together. Prior to August 2007, banks in the U.S. Libor panel submitted similar, often identical quotes. In this pre-crisis period, the CDS spreads for panel banks have also been similar and low. This behavior changed with the onset of the financial crisis in 2007, with the intra-day variation of both Libor quotes and CDS spreads increasing from their historical levels. The intra-day variation of CDS spreads, however, grew considerably larger than that of Libor quotes. Figure 3 shows histograms of 12 month Libor quotes, normalized by subtracting the value of the day's fourth highest quote for each bank quote. An identical procedure is performed for 1 year CDS spreads.[7] Libor quotes are much more clustered around the day's fourth lowest quote than CDS spreads are of the fourth lowest spread. If banks were truthfully quoting their costs, however, we would expect these distributions to be similar.

There are several possible explanations for the bunching of quotes around the fourth lowest. The one that we pursue here is that some banks have incentive to alter the rate of the overall Libor and the bunching is a result of these incentives interacting with the rate setting mechanism. In the model that we lay out formally in the appendix, a bank's payoff, vis a vis it quote, is the sum of two terms. The first term is proportional to the Libor fix and captures the bank's incentives to change the rate. The second term is the "cost" of misreporting, for example the cost of a BBA investigation, which is triggered by unusual quotes. Bank incentives interact with the truncated averaging mechanism of the Libor. Consider a Libor panel member that knows the quotes of the

[6] Formally, suppose that costs are given by $c_{itm} = \alpha_{it} - \alpha_{mt} + \epsilon_{itm}$, where c denotes borrowing costs, and i, m, and t denote bank, market and time respectively. Differencing differences in bank quotes across markets gives: $(c_{itm} - c_{jtm}) - (c_{itm'} - c_{jtm'}) = \epsilon_{itm} - \epsilon_{jtm} - \epsilon_{itm'} + \epsilon_{jtm'}$. If the bank-currency specific shocks are such that the ϵ's are mean zero and i.i.d, we should see no rank reversals on average.

[7] We drop the day's fourth lowest quote and CDS spread from the data, in order to avoid spurious bunching around zero due to the fact that there is always a fourth lowest quote

15 other members on a given day.[8] Figure 5 shows graphically that bank's optimal quote problem, which requires equating the marginal benefits of changing the Libor with the marginal cost of misreporting. The marginal benefits function, which assumes the hypothetical bank's payoff is decreasing in the Libor, is a step function with a discontinuity at both pivotal quotes. The optimal quote is the intersection of the marginal cost curves and this step function, which bunches quotes representing a wide interval of true borrowing costs at (in this case) the lower one pivotal point.

There may be other explanations for why Libor quotes might be more closely clustered together than other measures of bank borrowing costs. The first is that, in this period, banks faced large reputational risks - bank runs on Northern Rock, Bear Stearns, and others were allegedly fueled by rumors of difficulty of raising funds from other banks. As suggested by Mollenkamp and Whitehouse (2008), an otherwise healthy bank submitting a high quote in the Libor panel might appear to have such problems and, by the same token a bank that actually has these problems might have incentive to submit low quotes to convince the market otherwise.

It is important to note different banks may have different net exposures to the Libor. Some banks may profit from a higher overall Libor rate, others may profit from a lower overall rate, and others still might be perfectly hedged. With this in mind, we examine the clustering behavior of individual banks, four of which are shown in figure 6. Here we see that Citigroup and Bank of America tend to submit quotes that are identical to the fourth lowest quote of the fifteen other banks, while this is not the case for WestLB. This is consistent with Bank of America and Citigroup having incentives, potentially stemming from their possession of Libor-indexed contracts, to lower the overall Libor rate, while WestLB does not have such incentives.

3.1 Constructing the Correct Libor: Eurodollar Bid Rate

The Eurodollar Bid Rate is a market rate for eurodollar deposits. Eurodollars are dollars held by banks outside of the United States, and have historically been an important source of funding for large American banks. We also show that the Eurodollar Bid Rate has had a historically tight relationship with the Libor. Prior to August 2007, indeed for the whole history of the Libor prior to then, the banks submitted quotes between 6 to 12 basis points above the Eurodollar Bid Rate. Banks were treating the Libor, the London Interbank *Offered* Rate, as their perception of the ask rate corresponding to the listed bid rate for Eurodollars. The Eurodollar Bid Rate-Libor spread of 6-12 basis points was then simply something like a bid-ask spread. Since 2007, for the first time the Libor descended below the Eurodollar Bid Rate and at times quite dramatically. Figure 7 shows the Eurodollar-Libor spread which is slightly positive prior to August 2007 and then drops dramatically once the Libor drops below the Eurodollar rate.

[8] Simple forecasting models do an excellent job in predicting the levels of Libor quotes during 2009. This is because Libor is adminstered with a daily frequency and Libor quotes move in a slow and predictable manner. We also note that the basic insight of the model can be extended to the case where there is uncertainty about the exact location of the pivotal quotes.

In table 2 we perform a structural break test to show the collapse of this historic relationship. We can see that, both in levels and in differences, the previous days Eurodollar Bid Rate was more important for determining the following days Libor than the previous Libor rate. This suggests that, prior to the crisis, banks simply observed the preceding days Eurodollar Bid Rate and added a fixed spread. After the crisis, however, the Eurodollar Bid Rate has much less predictive power on the following days Libor. The lagged Libor rate instead becomes much more important as it drops below the Eurodollar rate. The chow test statistic is for a test of the null of no structural break in August of 2007.[9]

Table 2: Structural Break Test

	U.S. Libor	
	Levels	Differences
Eurodollar Bid Rate	0.608	0.696
	(0.033)	(0.031)
U.S. Libor	0.392	-0.123
	(0.033)	(0.032)
Eurodollar Bid Rate	-0.605	-0.589
* **1**(After August 2007)	(0.034)	(0.034)
U.S. Libor	0.600	0.586
* **1**(After August 2007)	(0.034)	(0.034)
N	1911	1392
R^2	1.000	0.423
Chow Test Statistic	175.07	148.5

Dependent variable is the current days Libor. All right hand side variables are lagged.

In their recent study, Abrates-Metz et. al. (2008) investigate the possibility of collusion among Libor panel banks in the post August 2007 period. A commonly used screen for collusion tests for whether cross sectional prices-or quotes in this case-have lower variance during the suspected collusion period relative to a benchmark period. They find that the variance is substantially *lower* in the benchmark pre-August 2007 period. Our results suggest the answer for this is that in the benchmark period, banks are coordinating on the previous days Eurodollar rate. Though, the cross sectional variance in costs presumably also increased dramatically in the period after August 2007.

The above results suggest an obvious counterfactual to construct: What would Libor quotes have been had banks continued to follow their pre August 2007 rule? We first calculate this rule

[9]The statistic follows an $F(4, 2999)$ distribution.

by running the regression in table 2, bank by bank. To give a sense of the magnitudes of skewing generated by this model, table 3 shows the average and standard deviation of bank quote "skewing", assuming the pre-August 2007 rule gives the correct quotes. Again, it is evident that measures of manipulation are stronger in the period when market turmoil had partially subsided. Manipulation is not the only explanation for the break between the Eurodollar rate and Libor quotes. Cassola, Hortacsu, and Kastl (2009) point out that, because of the lack of actual transactions in the interbank market during the crisis period, Libor quotes were uninformative as the banks themselves had little information. However, it is unclear, from this theory why quotes would be biased downward, or why banks would abandon the Eurodollar Bid Rate as a coordination mechanism. An alternative explanation is that the lack of market data lowered the cost of misreporting as market observers had fewer, accurate benchmarks with which to compare Libor quotes. We also note that the break is broadly consistent with the reputational explanation for misreporting but, again, it is puzzling that quote behavior has not started to revert to past behavior despite the calming of markets.

Table 3: Average Magnitude of Quote Skewing: Eurodollar Bid Rate - Libor Quote

	Pre Aug. 07		Aug. 07 - Aug. 08		Post Jan. 09	
Bank	mean	sd.	mean	sd.	mean	sd.
Barclays	.02	.01	-.081	.10	-.37	.13
Bank of America	.02	.02	-.11	.10	-.393	.14
Bank of Tokyo-Mitsubishi	.029	.01	-.095	.10	-.320	.14
Citigroup	.022	.01	-.118	.10	-.400	.13
CSFB	.022	.01	-.097	.10	-.370	.13
Deutsche Bank	.02	.01	-.106	.10	-.412	.14
HBOS	.023	.01	-.111	.10	-.382	.13
HSBC	.022	.01	-.11	.10	-.51	.13
J.P. Morgan	.023	.01	-.111	.11	-.434	.13
Lloyd's	.022	.01	-.108	.11	-.381	.13
Norin	.03	.02	-.090	.10	-.31	.14
Rabo Bank	.022	.01	-.111	.10	-.403	.13
RBOS	.019	.01	-.097	.10	-.301	.12
Royal Bank of Canada	.015	.01	-.119	.10	-.345	.10
UBS	.022	.01	-.111	.10	-.361	.11
WestLB	.022	.01	-.098	.10	-.333	.17

4 Sources of Misreporting Incentives

Having established evidence of misreporting, we now turn our attention to the sources of misreporting incentives. We argue bank portfolio exposure to the Libor is a good candidate for generating these incentives. In general, these portfolio positions are opaque and for this reason we focus our analysis on the three American bank holding companies. These banks are required to provide information about their interest rate derivatives and net interest revenue in the quarterly Reports on Conditions and Income (Call Reports) to the FDIC. The level of detail is still not as fine as would be necessary to perform a thorough analysis, so we emphasize the suggestive nature of the results presented in this section and hope they will lead to a more complete analysis.

Interest rate swaps are a very popular type of interest rate derivative and these three banks hold many of them.[10] Table 4 shows the notional value of the interest rate swaps held by these banks. The Libor is the most commonly used floating rate for swaps, with the 3 month and 6 month U.S. Dollar Libor being the most popular for U.S. Dollar interest rate swaps. Given the large notional values, a small unhedged exposure to the Libor can generate large incentives to alter the overall Libor. If J.P.Morgan, for example, had a swap position with just a 1% net exposure to the Libor in the fourth quarter of 2008, then its costs on its contracts would be proportional to $540 billion. If it was to succeed in modifying the Libor by 25 basis points in a quarter it would make $1/4 * 540 * .025 = 0.337$ or $337 million in that quarter. If it had a 10 percent net exposure it could make $3.37 billion.[11]

[10] An interest rate swap is an agreement between two parties, where one pays a fixed interest (the Payer) rate in return for a floating or variable rate from the other party (the Receiver). If f is the fixed rate and L_t is the floating rate at a payment period t for such a contract, then the Payer recieves $(L_t - f)V$ and the Receiver receives $(f - L_t)V$ where V is the *notional value* of the contract. While similar to a principal, the notional value is never exchanged and exists solely for computing payments.

[11] Note we are focusing solely on swaps, a contract which has a payout that is linear in the Libor. These banks also participate heavily in other more complex derivatives, such as 'swaptions' - options to purchase swaps, whose payoffs may be substantially nonlinear in the Libor.

Table 4: Notional value of Interest Rate Swaps (millions)

Quarter	Citigroup	Bank of America	JPMorgan Chase
2007.1	15.712.307	19.305.479	43.357.920
2007.2	16.133.587	19.873.919	49.287.878
2007.3	18.371.402	22.339.658	59.919.028
2007.4	16.955.132	22.472.948	52.097.878
2008.1	19.585.284	25.261.266	55.188.126
2008.2	18.732.046	26.162.587	59.821.075
2008.3	17.360.100	26.230.767	54.907.116
2008.4	15.859.923	26.577.385	54.524.046
2009.1	14.177.696	49.717.209[a]	49.282.465
2009.2	15.613.216	49.577.518	48.914.118
2009.3	15.230.030	48.676.584	48.893.217

Source: Bank Holding Company FR Y-9C Reports.

a. Bank of America completes merger with Merrill Lynch.

Many interest rate derivatives held by banks are held for the purpose of hedging other items on the balance sheet, so notional portfolio sizes can be misleading. Perhaps the best picture of aggregate exposure is given by aggregate revenue that banks earn from their derivative portfolios. Table 5 shows the net interest revenue banks have made over the last 2 years, including the contribution of trading revenue on interest rate derivatives. Notably each of the three banks experience large net revenue increases in the first quarter of 2009, when the Libor fell dramatically.

Table 5: Net Interest Revenues ($m)

Quarter	Citigroup	Bank of America	JPMorgan Chase
2007.1	12.129	9.182	6.887
2007.2	13.032	8.683	7.455
2007.3	13.774	7.026	8.961
2007.4	14.046	3.803	6.561
2008.1	12.366	10.394	7.567
2008.2	13.664	11.725	8.760
2008.3	11.527	11.832	6.084
2008.4	7.728	12.888	11.271
2009.1	18.248	14.034	15.214
2009.2	12.355	15.078	14.081
2009.3	13.741	11.042	14.189

Source: Bank Holding Company FR Y-9C Reports. The shown values are the sum of reported Net Interest Revenue and Trading Revenue on Interest Rate Derivatives.

The bunching on the lower discontinuity shown earlier in figure 6 suggests that some banks like Citigroup may have incentives to alter the rate while others may not. Table 6 shows Citigroup's reported counterfactual gains from movements in interest rates for several different currencies. In the first quarter of 2009 Citigroup reported it would make $936 million in net interest revenue if interest rates would fall by 25 basis points a quarter over the next year and $1,935 million if they were to fall 1 percent instantaneously. In terms of exposure to Yen interest rates however, Citigroup reports it would make $122 million if Yen interest rates were to rise gradually and $195 million if they rose by 1 percent instantaneously. Citigroup's exposure to the Euro switches signs and is generally low. Figure 8 shows Citigroup's quotes relative to the upper and lower discontinuities in all three currencies. Citigroup's U.S. quotes are bunched on the lower discontinuity of the U.S. Libor while its Yen quotes are bunched on the *upper* discontinuity in the Yen Libor, consistent with the direction the model and table 6 would suggest. Further, Citigroup's Euro quotes appear to bunch less on the discontinuities, which is consistent with its apparently smaller incentives to alter Euro rates.

Table 6: Citigroup's Counterfactual Net Interest Revenues ($m)

	1% Instantaneous Increase			1% Instantaneous Decrease		
	U.S. Dollar	Euro	Yen	U.S. Dollar	Euro	Yen
2009.3	-1,193	52	228	1,427	-4	NM
2009.2	-1,767	-29	215	1,935	21	NM
2009.1	-1,654	11	195	1,543	-12	NM
2008.4	-801	-56	172	391	57	NM
2008.3	-1,811	-52	142	893	52	NM
2008.2	-1,236	-71	131	1,170	71	NM

Instantaneous means a 'parallel instantaneous 100bp change in rates.'

	1% Gradual Increase			1% Gradual Decrease		
	U.S. Dollar	Euro	Yen	U.S. Dollar	Euro	Yen
2009.3	-563	12	135	526	-12	NM
2009.2	-1,005	-35	122	936	35	NM
2009.1	-888	12	122	660	-12	NM
2008.4	-456	-43	51	81	43	NM
2008.3	-707	-41	72	490	41	NM
2008.2	-756	-51	73	633	51	NM

Gradual means 'a more gradual 100bp (25bp per quarter) parallel change in rates.'

NM - Not Meaningful; a 100bp reduction would result in negative rates.

Source: Citigroup's 10-K and 10-Q reports.

5 Conclusion

In this paper we have presented new evidence corroborating concerns that Libor panel banks may be understating their true borrowing costs. Previous analysis of the problem have suggested the cause of this misreporting is the desire of panel banks to appear strong, especially during the recent banking crisis. In contrast, our theory of misreporting incentives points to a more fundamental source, namely that bank portfolio exposure to the Libor give them incentives to push the rate in a direction favorable to these positions. Our theory, then, suggests that the rate may perform badly even in times of market calm, whereas the reputation theory suggests that we may only have to worry during periods of severe market stress.

The nature of the Libor mechanism, which averages the middle eight quotes out of sixteen, helps us formulate a novel strategy for testing the theory. When the location of the "pivotal"quotes are highly predictable, as they appear to be in our sample, banks with incentive to manipulate the

Libor fix bunch around these quotes because the marginal change in the fix drops discontinuously there. Borrowing costs, on the other hand, presumably have no relationship with these pivotal points and so neither should quotes from banks with no incentives to manipulate the fix.

Understanding the sources of misreporting incentives has important policy implications. Concerns about the Libor's accuracy has led a large money market broker ICAP to recently launch the 'New York Funding Rate' which is intended to replace the Libor. The primary innovation of the New York Funding Rate is that submitted quotes are anonymous. This reflects the view that the primary motive for banks to submit downward or misleading quotes is to signal their strength or soundness. If, in addition, a major incentive for banks to misreport their true borrowing costs is to influence the overall rate of the Libor, as we suggest, anonymity may actually make it easier for banks to misreport. Though there may be many other reasons for it, it is interesting to note that the New York Funding Rate has often been lower than the Libor throughout 2009.

As in the reputation enhancement story of misreporting, the primary problem our theory points to is that in the Libor, and similar indexes derived from surveys, participants face little in the way of costs for submitting false or misleading quotes. Creating a system that properly incentivizes truthful reporting would require major changes and possible unintended consequences would have to be carefully weighed. On the other hand, our theory suggests a simple approach based on diminishing the incentives for misreporting by adding more banks to the panel. Just as adding firms to a market (usually) makes a market more competitive by reducing the impact any one firm has on price, adding banks to the panel would lower the marginal impact any one bank would have on the rate.

Appendix

We now introduce a simple model of how member banks submit their quotes. Let $i = 1, \ldots, 16$ be the banks in the Libor panel for a given currency and tenor. Let $t = 1, \ldots, T$ denote the days where the Libor was administered. We let $q_{it} \in [0, \bar{q}]$ denote the quote of bank i at date t. The Libor fix, $L_t = L(q_{it}, q_{-it})$, is then the average of the middle 8 quotes. The true borrowing costs of each bank is denoted $c_{it} \in \mathbf{R}_-$ and the profile of costs c_t is distributed according to the joint distribution F_t. We write the net "profit" accruing to bank i in period t as:

$$\Pi_{it}(q_{it}, q_{-it}, c_{it}) = v_{it} L(q_{it}, q_{-it}) + \pi_{it}(q_{it}, q_{-it}, c_{it})$$

where v_{it} is the bank's portfolio exposure to the Libor and π_{it} captures the reputational motives of the bank. We allow the reputational concerns reflected in π_{it} to depend on the quotes of other panel banks and its true borrowing cost, c_{it}. This is consistent with our favored interpretation that bank portfolio positions give them an incentive to manipulate the Libor, but they face reputational or other costs for being too far away from other banks and, potentially, for setting quotes too far

from their actual costs of borrowing. Note that they are subscripted by bank and time, so we allow for incentives to vary due to, for example, changing bank portfolios.

We choose to model a bank's payoffs as linear in the Libor as the majority of contracts have linear payouts. Adjustable rate mortgages, futures, forwards, swaps and corporate loans all have linear payouts in their underlying reference index, often the Libor. A portfolio composed entirely of these contracts would itself have a payout linear in the Libor, and although these banks likely do possess a small amount of nonlinear contracts, we consider linearity to be a good approximation. We also assume that π_{it} is continuously differentiable, strictly concave in q_{it} and $\frac{\partial^2 \pi_{it}}{\partial c_{it} \partial q_{it}} > 0$. These latter assumptions reflect our view that banks suffer reputational penalties for submitting increasingly 'extreme' quotes and for quotes that are far away from their true costs. We also assume that F_t is absolutely continuous and has full support on $\mathbf{R}^{16}$.

Let $\ell(q_{-it})$ denote the fourth lowest quote of q_{-it} and $r(q_{-it})$ is the fourth highest. From i's perspective, these are the points where the marginal response of the Libor changes discontinuously. We now state a proposition that forms the basis of our prediction we should see bunching around the pivotal quotes $\ell(q_{-it})$ and $r(q_{-it})$.

Proposition 1 *Let q_{-it} be such that $\ell(q_{-it}) < r(q_{-it})$. Then if $v_{it} < 0$ (> 0) there is an interval of costs where i's best response is to quote $q_{it} = \ell(q_{-it})$ $(= r(q_{-it}))$. Moreover, the width of this interval is increasing in $|v_{it}|$.*

Proof: Suppose that $v_{it} < 0$. Whenever costs are such that

$$-\frac{v_{it}}{8} > \frac{\partial \pi_{it}(q_{it}, q_{-it}, c_{it})}{\partial q_{it}}\Big|_{q_{it}=\ell(q_{-it})} \tag{1}$$

$$0 < \frac{\partial \pi_{it}(q_{it}, q_{-it}, c_{it})}{\partial q_{it}}\Big|_{q_{it}=\ell(q_{-it})} \tag{2}$$

then $\ell(q_{-it})$ is a local optimum. If, further

$$0 > \frac{\partial \pi_{it}(q_{it}, q_{-it}, c_{it})}{\partial q_{it}}\Big|_{q_{it}=r(q_{-it})} \tag{3}$$

then $\ell(q_{-it})$ is a global optimum. This follows from the concavity of π_{it} in q_{it} which ensures $\partial \pi_{it}/\partial q_{it}$ is decreasing in q_{it}. The other discontinuity, r, is not a local equilibrium. Our assumption on the cross derivatives ensures that $\partial \pi_{it}/\partial q_{it}$ is strictly increasing in c_{it} and is thereby invertible in c_{it}. Inverting equations (2) - (4) conditional on q_{it} and q_{-it} defines an open interval of costs which is weakly increasing in $-v_{it}$. A symmetric argument follows for the case when $v_{it} > 0$. □

This proposition, combined with the absolute continuity and full support of F_t, will deliver a point mass at $r(q_{-it})$ or $\ell(q_{-it})$ in the distribution of q_{it} conditional on q_{-it}. This logic extends to a perfect information game as well.

Proposition 2 *Let $v_{it} < 0$ for some bank i and let $c_t = (c_{1t}, \ldots, c_{16t})$ be a given profile of borrowing costs. If there is a Nash equilibrium q_t^* where $q_{it}^* = \ell(q_{-it}^*) < r(q_{-it}^*)$ then there is an interval (c^l, c^u) of costs for i such that for any $\tilde{c}_{it} \in (c^l, c^u)$, q_t^* remains a Nash equilibrium for the new cost profile $\tilde{c}_t = (c_{1t}, \ldots, \tilde{c}_{it}, \ldots, c_{16t})$.*

Proof: If $q_{it}^* = \ell(q_{-it})$ is optimal, it is necessarily a local equilibrium, so equations (5) and (6) must hold for q_{it}^*. The only possible other optimal solution is $\tilde{q}_{it} > r(q_{it})$ that satisfies the first order condition $\partial \pi_{it}/\partial q_{it} = 0$. As q_{it}^* is optimal, it must be $\Pi(q_{it}^*, q_{-it}, c_{it}) \geq \Pi(\tilde{q}_{it}, q_{-it}, c_{it})$ or equivalently,

$$-v_{it}[r(q_{-it}) - \ell(q_{-it})] \geq \int_{\ell(q_{-it})}^{\tilde{q}_{it}} \frac{\partial \pi_{it}}{\partial q_{it}} \, dq_{it} \tag{4}$$

As $\partial \pi_{it}/\partial q_{it}$ is increasing in c_{it} for each q_{it}, the right hand side of (8) is increasing in c_{it}. So for any $\tilde{c}_{it} < c_{it}$, (8) is satisfied, and if $\tilde{c}_{it}$ satisfies (5) and (6) as well then it remains optimal for i to quote q_{it}^* for costs in this interval. As i quotes the same, and no other cost has changed, it remains a best response for every other bank to quote q_{-it} and q_t^* remains an equilibrium for the new cost profile containing $\tilde{c}_{it}$.

References

[1] M. Kraten A. Metz Abrantes-Metz, R. and G. Seow. Libor manipulation? Mimeo, August 2008.

[2] C. Mollenkamp and M. Whitehouse. Study casts doubt on key rate:wsj analysis suggests banks may have reported flawed interest data for libor. *The Wall Street Journal*, May 28, 2008.

[3] A. Hortacsu N. Cassola and J. Kastl. The 2007 subprime market crisis through the lens of european central bank auctions for short term funds. University of Chicago Working Paper, July 2009.

[4] J. Taylor and J. Williams. A black swan in the money market. *American Economic Journals: Macroeconomics*, 1:58 83, 2009.

Figure 1: One Year LIBOR Quotes and CDS Spreads

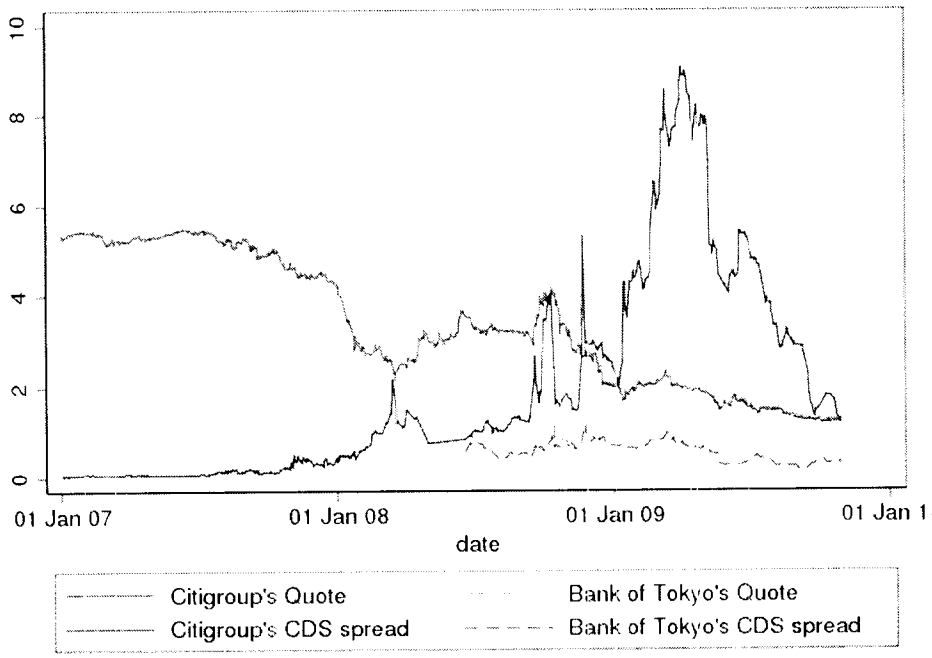


Figure 2: Cross Currency Bank Reversals

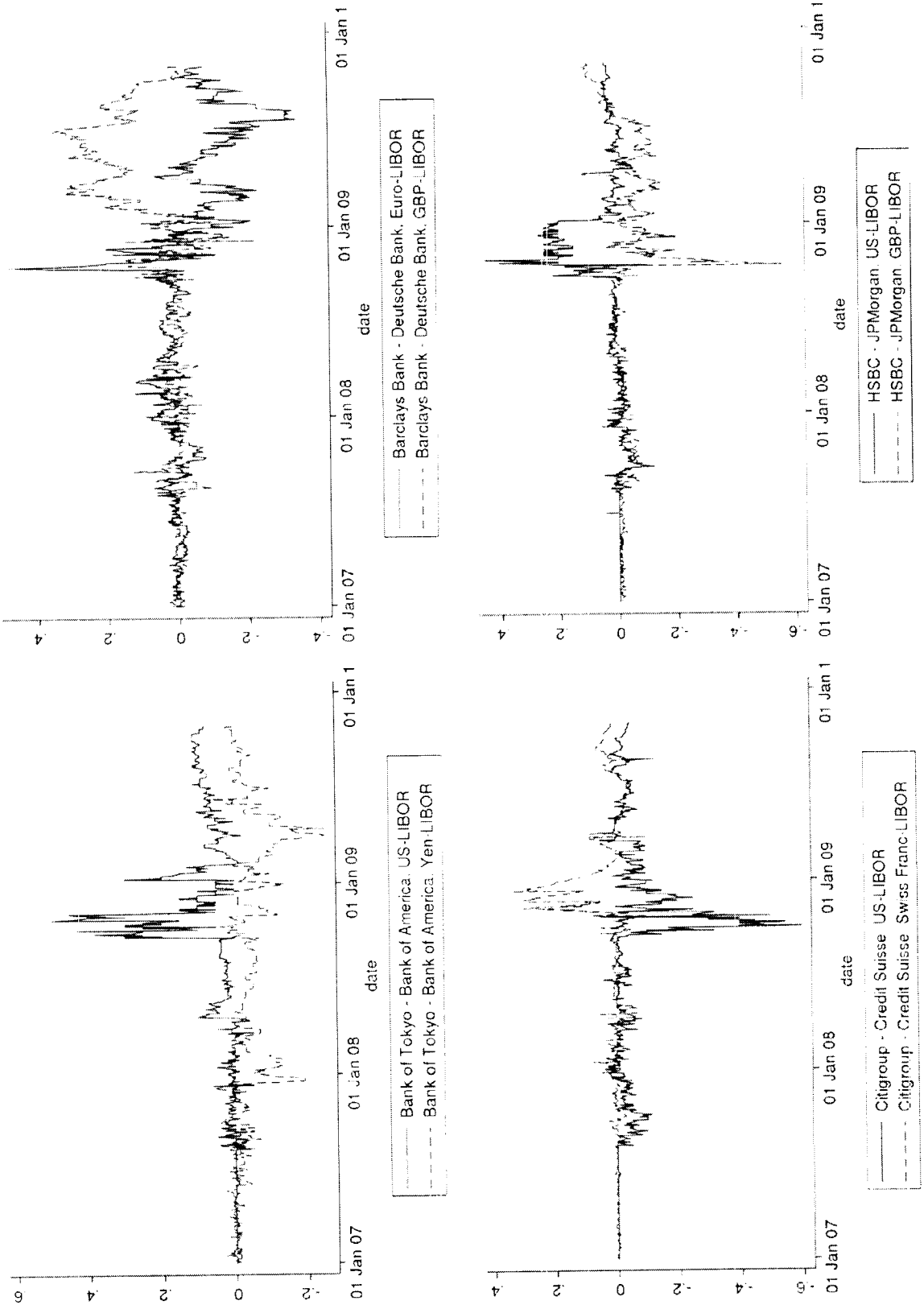
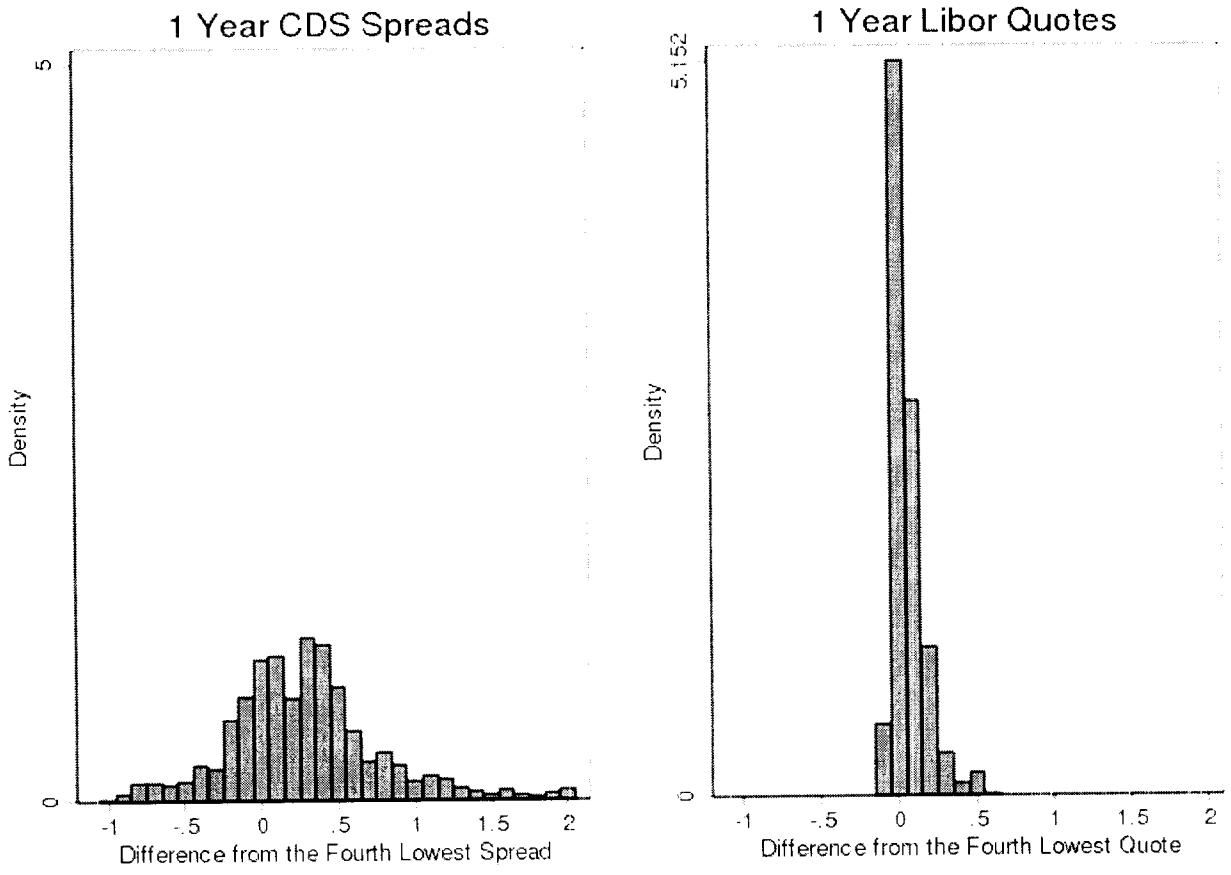
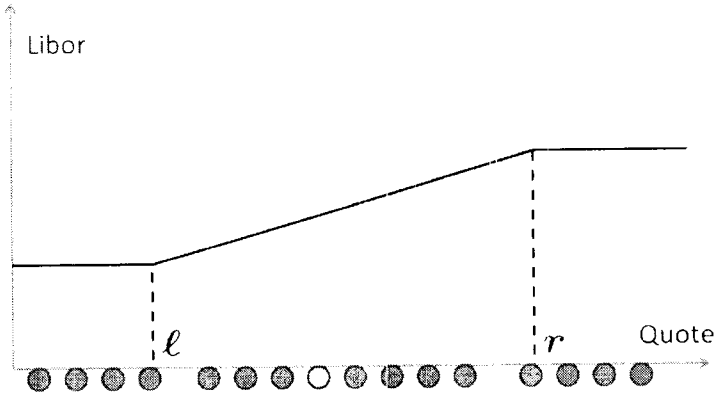


Figure 3: Distribution of Libor Quotes and CDS Spreads



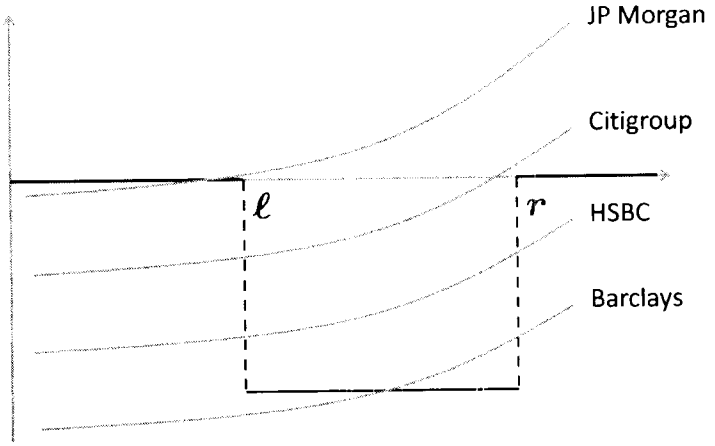
12-Month U.S. Libor quotes and 1-Year Senior CDS spreads.

Figure 4: Responses in the Libor to a Bank's Quote



The circles represent the quotes of the 16 banks. The four highest and four lowest quotes are dropped and the average of the remaining eight quotes determines the Libor rate. Shown is the counterfactual Libor rate if one of the middle eight banks were to change their quote.

Figure 5: Discontinuities in the Marginal Response of the Libor



Shown is the marginal benefit and cost curves for banks whose portfolios are such that they profit from a lower overall rate of the Libor.

Figure 6: Clustering of Libor Quotes around Discontinuities in the 3 Month U.S. Libor

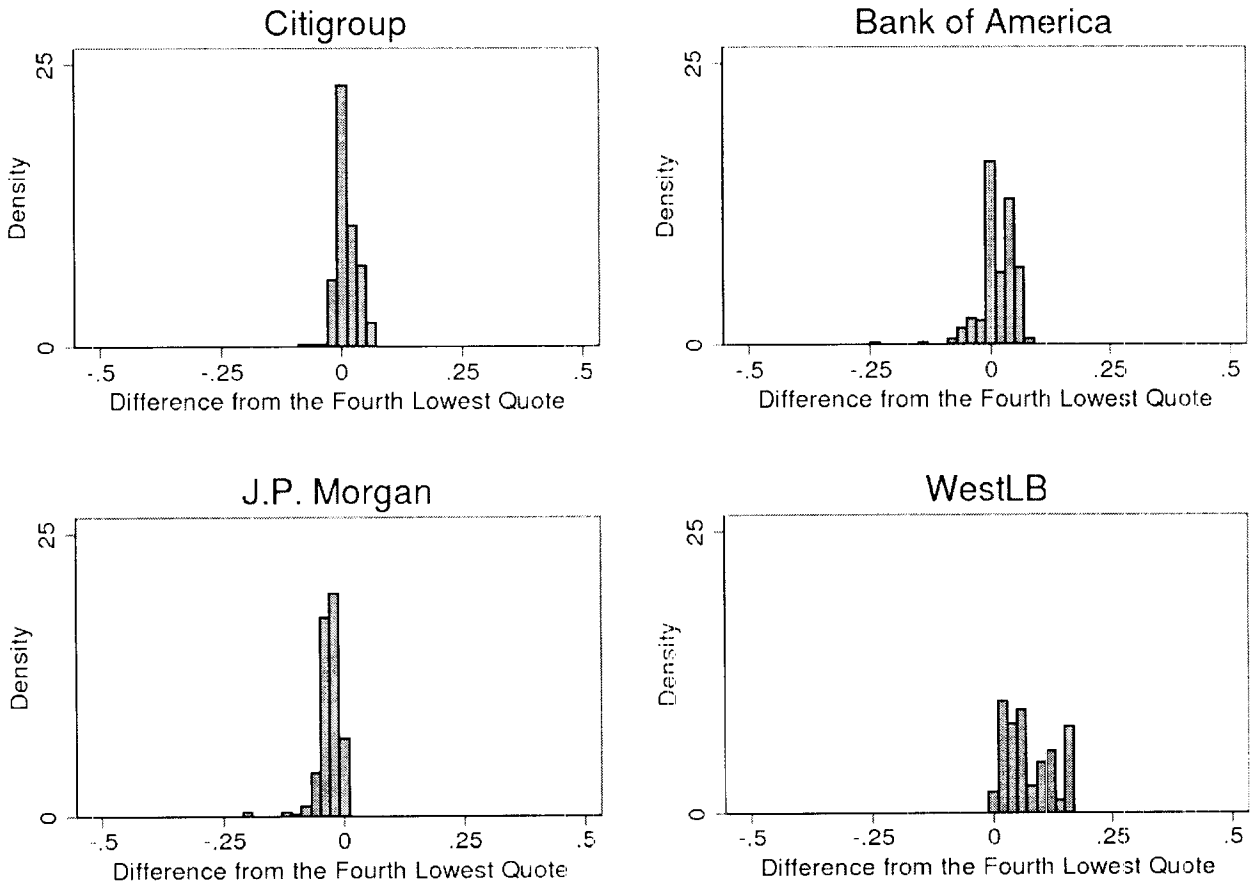


Figure 7: 3 Month Eurodollar - U.S. Libor Spread

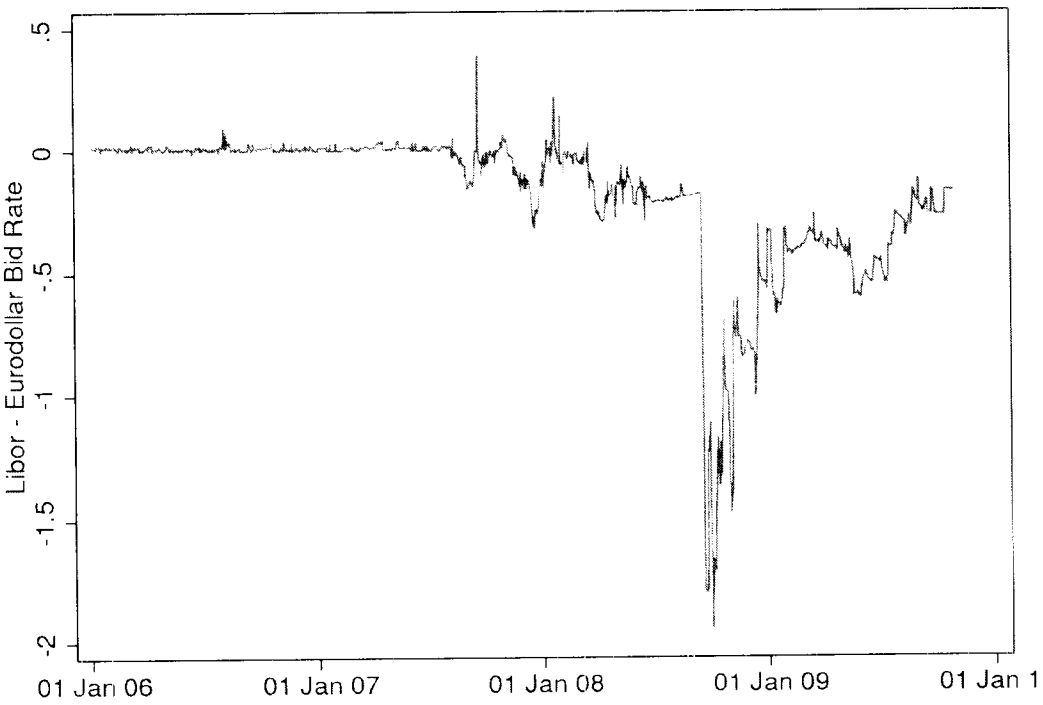
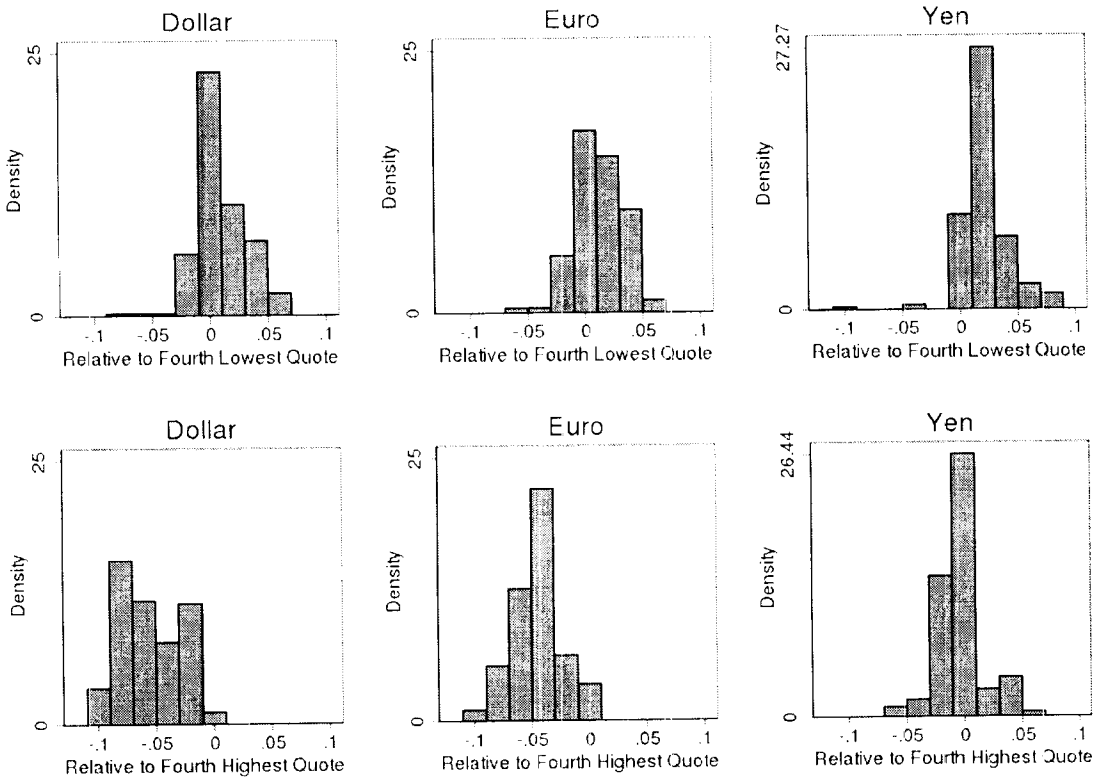


Figure 8: Citigroup's Quotes Across Currencies



Citigroup's quotes are clustered on the lower discontinuity in the U.S. dollar Libor while clustered on the upper discontinuity in the Yen Libor. As shown in table 6, Citigroup profits from lower U.S. interest rates and a higher Yen interest rates.

EXHIBIT 7

City of Detroit

Kenneth V. Cockrel, Jr. Mayor

Planning and Development Department

Neighborhood Stabilization Program Plan

Douglass J. Diggs, Director

Marja M. Winters, Deputy Director

- Invest in select neighborhoods to achieve greater impact with limited resources especially neighborhoods targeted by LISC, Skillman, the Community Foundation and NDNI
- Protect recent investments by public and private partners
- Attract other public/private financing to leverage NSP funds minimally on a 2:1 basis
- Create new jobs and stimulate small business development
- Demolish existing structures to accommodate future development or alternative uses.

Foreclosure Problem

As evidenced by Detroit's NSP award amount, which was allocated under a formula developed by the Department of Housing and Urban Development taking into account the numbers of foreclosures, subprime loans and defaults in each jurisdiction, Detroit has the highest home foreclosure rate among the nation's 100 largest metropolitan areas, making it one of the cities hardest hit by the national foreclosure and sub-prime lending crisis. The impact of not dealing aggressively with this crisis would have tremendous implications for the economic survival and social viability of the city. Moreover, the toll on Detroit citizens and families will be devastating as once stable neighborhoods are faced with increased blight, vacant properties and diminished housing values. Thus, it is imperative that we strategically focus our resources to achieve the greatest outcomes and thwart further decline.

Statistics on local foreclosure activity speak volumes about the crisis in Detroit. From 2004 to 2006, there were approximately 330,000 mortgages originated in Detroit. During the same time, 38,000 new mortgages were sold representing 11% of total mortgages. About 27,500 or 73% of new mortgages were high cost loans defined as loans with interest rates at least 3% above Treasury securities. Refinances accounted for 15% of new mortgage loans. As of 2006, about 29,000 adjustable rate mortgages or 9% of all existing mortgages reset, triggering higher payments for loan recipients. An additional 16,000 mortgages are scheduled to reset from 2008 to 1010. These statistics clearly demonstrate that additional resources will be needed to prevent future foreclosures and the number of Detroit homeowners that are expected to be impacted by the nearing reset activity.

The result of the exorbitant numbers of high cost loans in Detroit is disturbing. From 2005 to 2007, Detroit experienced an astounding 67,000 foreclosures, more than 20% of all household mortgages. There were 4,600 tax foreclosures in the first six months of 2008 with over $25 million in taxes due on these properties. Early estimates indicate that at least two-thirds of tax or mortgage foreclosed properties stand vacant causing tremendous problems for Detroit on many levels.

A foreclosed property that stays on the market for an extended period of time can become an administrative and economic drain on a city; a study by the Homeownership Preservation Foundation found that a city can lose about $20,000 per home in lost property taxes, unpaid utility bills, property upkeep, sewage and maintenance. High foreclosure rates also causes disinvestment by nearby residents, which contributes to neighborhood decline, affects surrounding property values, and leads to population loss and increased crime.